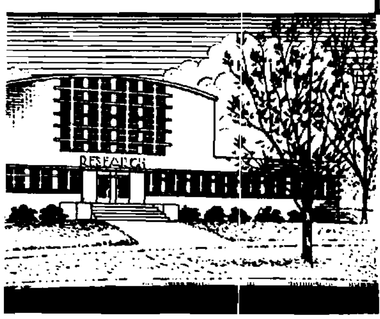
Project B-166-1

COASTAL BERMUDA MEAL
An Industrial Possibility for Georgia

Prepared for
The Georgia Department of Commerce
Abit Massey, Director

by
A. Eugene Queen



Engineering Experiment Station
Georgia Institute of Technology
Atlanta, Georgia

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C O A S T A L   B E R M U D A   M E A L

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Foreword

This is the first of a series of studies of opportunities for establishing plants in Georgia's smaller and more rural communities which will be completed during the coming months as part of a new project for the Georgia Department of Commerce. By focusing on possibilities open to the smaller towns, which generally have a more difficult problem attracting industry, the project aims to fill a gap in the State's industrial development program.

The announcement just before this report went to press that a $250,000 pelletizing plant is to be built in Cairo, Georgia reflects the intense interest in Coastal Bermuda which prompted this study. The origins of the report can be traced back to a request for data on the food value of pelletized Bermuda which was brought to the Engineering Experiment Station almost a year and a half ago. Prior to the time Mr. Queen's investigation was made possible through the initiation of the Department of Commerce's new project, we had been strongly encouraged to undertake such a study by individuals interested in learning whether sufficient information was available to warrant the establishment of pelletizing plants at various locations in Georgia. A number of persons and firms had provided the stimulus and financial support necessary to complete preliminary chemical analytical work.

Mr. Ed M. Parker, District Agronomist of the Spencer Chemical Company, and Mr. Penn Worden, Manager of the Industrial Department of the Georgia State Chamber of Commerce, in particular should be cited. Through their efforts, funds needed for chemical tests of Bermuda meal samples were contributed by the Southern Natural Gas Company, Charles Vantress Farms, Inc., and the Spencer Chemical Company.

As the report points out, the recommended economic feasibility analysis and the additional feeding tests now underway or planned can provide a complete picture of the promise Coastal Bermuda offers for the development of an important new industry in Georgia. In the meantime, we feel that the presentation of the data currently available will be of real value to many who are interested in the pelletizing of Bermuda grass.

Kenneth C. Wagner, Head
Industrial Development Branch

Acknowledgments

As is the case in any report based on a literature search, the original investigators deserve recognition as the primary source of any merit this report may contain. Their contributions are acknowledged as they appear. Others, some of whom are not mentioned in the documentation, are singled out here as being especially helpful and cooperative.

Transportation cost data were supplied by Mr. Claude Newman, Georgia Ports Authority; Mr. Harry T. Thacker, Hoover Motor Express, Inc.; Messrs. Robert C. Dryden and John C. Henderson, Georgia Highway Express, Inc.; and Mr. H. E. Robbins, Atlantic Coast Line Railroad Company.

The Academic Press, Incorporated, kindly granted permission to quote pertinent sections of Processed Plant Protein Foodstuffs, and the authors of the various opinions of the chemical analysis contained in Section V consented to have their remarks quoted from private communications.

The data supplied by Dr. A. E. Cullison, of the University of Georgia, are published for the first time. This courtesy deserves special acknowledgment.

Dr. Glenn W. Burton, Coastal Plain Experiment Station, considerately read the manuscript prior to publication. His encouragement is deeply appreciated.

Various members of the Industrial Development Branch gave advice and assistance, and prepared the report in final form.

Summary

This report is concerned with the possibility of establishing a dehydrated Coastal Bermudagrass industry in Georgia. The findings are the result of a literature search and contact with personnel of several agricultural experiment stations who have various interests in Coastal Bermuda.

In general terms, the findings are:

1. Coastal Bermuda yields far surpass alfalfa yields obtained in this area, and are comparable to alfalfa yields obtained under favorable conditions in the Midwest.

2. The evidence obtained so far indicates that Coastal Bermuda can be directly substituted for alfalfa in prepared feeds, and shows much promise as a superior winter forage for cattle.

3. The available evidence is sufficient to justify the added emphasis of economic investigations. A comprehensive feasibility analysis should be initiated immediately so that local citizens may derive the most benefit from early entry into production at a minimum risk.

The tests from which these conclusions have been drawn are relatively few in number. They demonstrate what can be done under controlled conditions. More tests, particularly in animal nutrition, are necessary before complete generalizations can be made. It should be noted, however, that several plants are entering production of dehydrated Coastal Bermuda on the basis of available information. A primary recommendation of this report is that more complete information, especially economic data, be provided as early as possible.

The question of feasibility must be considered from a number of viewpoints which, at the risk of oversimplification, may be conveniently labeled (1) agronomy, (2) nutrition, and (3) economics. Within this framework, the report outlines in summary form the findings of several southern agricultural experiment stations in the areas of agronomy and nutrition as they relate to Coastal Bermuda grass. In most cases, Coastal Bermuda is compared with alfalfa, the standard forage component of prepared feeds.

Economic considerations, with the exception of those implicit in agronomy and nutrition, have not received much attention in published reports. This is natural, as feasibility from the first two points of view must be indicated before it becomes worthwhile to consider aspects that might be termed purely economic.

The economic feasibility analysis recommended would include (1) a study of market data relating to alfalfa meal, (2) a survey of feed mills in Georgia (and perhaps neighboring states) to determine alfalfa meal usage, (3) an examination of trends in poultry and livestock production, (4) analysis of production costs experienced in existing dehydration plants, and (5) plant engineering recommendations. The analysis would also include an estimate of the profitability of Coastal Bermuda meal production.

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Tables (Continued)

I. Introduction

A goal of every poultry and livestock feeder is to supply an "optimum" diet: the most productive diet consistent with cost and market price limitations. It is immediately obvious that there are really two objectives, and the one may well be in conflict with the other. Nutritionists are constantly searching for feed components that result in more rapid weight gains when introduced into the diet of poultry or livestock, and, more importantly, require fewer pounds of feed per pound of weight gained.

Given alternative sources of "adequate" nutrition, the decision as to what the make-up of feeds will be, reflected in the quality of the feed mills' product, is basically an economic one. The costs incurred in production, of which feed cost is a major component, must be less than the revenues the feeder will receive for his final product when placed on the market. For this reason, production of low cost plant protein feeds has played an especially important role in the development of specialized segments of livestock and poultry production, as well as the prepared feed industry. Plant proteins are sometimes preferred for another reason: they may contain unidentified nutritive values not present in commercially available feed additives or concentrates.

It was noted long ago that green forages are much richer in food values, such as pro-vitamin A, than sun-cured hays. It was found that fast, artificial drying better preserved these food values. This discovery led to the development of a dehydration industry in the U. S. by the early 1930's, and alfalfa meal became the primary product of this industry.

The great beef-producing areas of this country coincide geographically with the major feed producing areas. Yet approximately 60% of the alfalfa meal produced in the Midwest is used in poultry feeds.[1/] Certainly the South (especially Georgia) is the major producer of poultry and poultry products. Further, beef cattle and swine are being produced in growing numbers in South Georgia and the potential for further expansion is enormous.

The production of dehydrated alfalfa meal is concentrated in the Midwest. This means that relatively high transportation costs are incurred in shipping it to feed mills in Georgia, even though water transport is used as far as Guntersville, Alabama, Memphis and Chattanooga, Tennessee. It follows that

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1/ C. Ray Thompson, "Alfalfa and Other Leaf Meals," Processed Plant Protein Foodstuffs, ed. Aaron M. Altschul (New York: Academic Press, Inc., 1958), p. 713.

the opportunity for production of a substitute for alfalfa meal, economically speaking, does exist--provided that the substitute is equal or superior to alfalfa in nutritive value, may be profitably produced, and is lower in cost to feed manufacturers.

There are indications that dehydrated Coastal Bermuda meal can meet these requirements. Assuming for the moment that it can, consider the direct benefits that would accrue to the state:

1. Coastal Bermuda would be a new cash crop for Georgia farmers--one perhaps more profitable than those now under governmental regulation.

2. Local production of a substitute for alfalfa would lower costs of production for feed manufacturers, or upgrade feeds now deficient in forage content.

3. Greater efficiency in feeding poultry and livestock would be obtained, provided Coastal Bermuda is superior in nutritive value, or that its use may be expanded where dietary considerations are now overweighed by cost considerations.

4. A dehydration industry would create considerable demand for power and fuel, and create some new employment in the production process.

The question, of course, is whether it can be demonstrated that Coastal Bermuda meal is an acceptable substitute for alfalfa, that production of dehydrated Coastal Bermuda on the required scale is feasible, and that other economic considerations are favorable. Work in progress at southern agricultural colleges should eventually provide sufficient data for a definite conclusion as to general acceptance by nutritionists and a realistic expectation of crop yield per acre.

This preliminary report attempts only to bring together for comparison some of the information available on alfalfa and Coastal Bermuda grass, and a brief summary of some of the results of experimental work at several southern agricultural experiment stations. It will be seen that the results are only a partial answer to the question of feasibility. Although economic questions will be considered in some of the research programs now in progress, an acceleration of this phase would seem to have certain advantages. As pointed out in Section V, some nutritionists are already convinced that Coastal Bermuda grass is acceptable as an alfalfa substitute. The North Carolina Department of Agriculture has approved this substitution in feeds consumed in that state.

When the opportunity for production of dehydrated Coastal Bermuda meal arises in Georgia, it would be helpful to have available for local citizens a study indicating the size and location of the market, estimated costs and returns, and other economic factors, rather than lose to others the opportunity for early entry into local production. This is an important consideration, since the dehydration industry is well adapted to rural areas which may often find industrial opportunities distressingly few.

Creation of new employment opportunities is probably the least significant of the advantages of local production of dehydrated meal that might be enumerated. More importantly, the existing disadvantage of high freight costs would be eliminated, enabling feed manufacturers to use as much dehydrated meal as is desirable from a nutritional standpoint, a practice which transport costs now discourage. This is especially significant for South Georgia, where feed consumption may be expected to increase tremendously with the growth of beef and swine production.

Georgia farmers would certainly welcome a new cash crop, especially when the crop is already in existance to the extent of over 500,000 acres. Proper management practices can transform some of this Coastal Bermuda acreage into a source of income, or at least a more profitable use than cover crops and pasture. An economic feasibility study would indicate how much a farmer could expect to receive from dehydrator operators for his Coastal Bermuda crop.

It should be emphasized that much basic research needs to be done, and is being done. The recommendation of this report is early attention to economic factors, considered as a necessary adjunct to basic research, but not as an emphasis which can in any way displace the vital work already being done in nutrition and agronomy.

II. An Alfalfa Substitute: The Context and the Need

Although dehydration of Coastal Bermuda may be thought of as an economic opportunity, it should be realized that there is a real need to take advantage of such opportunities as they arise. Otherwise, Georgia will not reach the level of economic well-being that is latent in her resources.

The state's position in broiler production and the potential for further development of cattle and swine production are well known, and need not be discussed at length. There is reason to believe that certain sections of Georgia can and will become important industrial and population centers. The increasing population of the state and the region will call for an increased food supply, as well as shifts to better quality of certain foods as income increases. This is especially true of locally produced beef and pork.

There need not be the geographic specialization that occurred in the West--cattle raising in the Southwest, fattening and finishing in the Midwest. The land to sustain the animals, land for feed crops, a long growing season, known and new techniques for improving crop production, all combine to give Georgia an agricultural base for making animal production self-sufficient within the state.

Thus, the evolution of the industrial and demographic traits of the state will be accompanied by a need for changes in agricultural patterns. These activities are complementary rather than competitive.

If the citizens of the state attempt to foresee the needs of the future, and match these needs with opportunities for resource development, they must regard changes in economic structure as one complex process. After, and only after, they have planned the guidance of change with all the ingenuity they can muster, should they regard problems as being, in a narrower context, specifically agricultural or industrial. Then a specific focus becomes necessary. Development plans must be translated into concrete, workable guides for action.

Georgia has no monopoly in economic potential. The competition in economic development among the states of this region is intense. Any economic opportunity of merit unrecognized in Georgia will surely be exploited elsewhere. In general, this lessens the likelihood of success of belated efforts in this state, and justified some sense of urgency in investigating enterprises that seem to have promise of feasibility.

It is within this context that the present report has been prepared. As noted elsewhere, this report is not a feasibility study in the broad sense.

The manufacture of prepared feeds has an obvious place in the state's present and future economy. Local production of feed ingredients, where feasible, is an equally obvious corollary. For these reasons, an early feasibility study of dehydrated Coastal Bermuda production is urged.

Transport Costs

To lend specific content to the claim for a need for an alfalfa substitute, data on freight costs for dehydrated alfalfa meal are presented in Table 1. At the time this report was written, the price of high quality dehydrated alfalfa meal (17% protein, 100,000 I. U. of Vitamin A per pound) was $60.00 per ton in the principal midwestern markets. From the freight cost data, it is apparent that these costs represent an increase of from 13 to 48% in the delivered price to Georgia feed mills. The price of $60.00 per ton is a high, seasonal figure. During the growing season, the price is reduced, making transport costs an even higher per cent of the basic price.

Table 1-A

FREIGHT COSTS PER TON, DEHYDRATED ALFALFA MEAL
ORIGIN, KANSAS CITY

Destinations	Rail Direct	Barge and Rail Via			Barge and Truck Via		
		Guntersville	Chattanooga	Memphis	Guntersville	Chattanooga	Memphis
Atlanta	17.00	10.75	11.17	14.42	16.25	16.67	22.52
Augusta	19.10	14.55	14.97	16.32	21.45	21.87	26.12
Bainbridge	19.20	14.75	15.57	15.32	21.85	23.07	24.32
Cartersville	16.20	10.15	9.57	14.22	15.65	15.07	21.92
Chamblee	17.00	10.75	11.17	14.42	16.25	16.67	22.52
Columbus	18.20	12.25	13.67	14.42	18.05	20.27	22.52
Cumming	17.30	11.75	11.97	14.82	17.45	17.47	23.32
Dalton	16.20	10.75	7.97	13.82	16.25	12.87	21.12
Flowery Branch	17.30	11.75	11.97	14.82	17.45	17.47	23.32
Gainesville	18.00	12.25	16.87	15.12	18.05	18.27	23.72
Hazlehurst	19.40	14.75	15.17	16.12	21.85	22.27	25.92
Savannah	20.00	15.55	15.77	17.22	23.65	23.47	28.12
Valdosta	20.10	15.15	15.57	16.12	22.65	23.07	25.92

Most favorable rates (i.e. truck & carload minimums) used for computations.

Sources: Computed from rate data supplied by Atlantic Coast Line R. R. Co., Hoover Motor Express, Inc., Georgia Highway Express, Inc., and Georgia Port Authority.

Table 1-B

FREIGHT COSTS PER TON, DEHYDRATED ALFALFA MEAL
ORIGIN, OMAHA

Destinations	Rail Direct	Barge and Rail Via Guntersville	Barge and Rail Via Chattanooga	Barge and Rail Via Memphis	Barge and Truck Via Guntersville	Barge and Truck Via Chattanooga	Barge and Truck Via Memphis
Atlanta	18.40	11.41	11.83	15.07	16.91	17.33	23.17
Augusta	19.90	15.21	15.63	16.97	22.11	22.53	26.77
Bainbridge	19.90	15.41	16.23	15.97	22.51	23.73	24.97
Cartersville	17.80	10.81	10.23	14.87	16.31	15.73	22.57
Chamblee	18.40	11.41	11.83	15.07	16.91	17.33	23.17
Columbus	18.80	12.91	14.33	15.07	18.71	20.93	23.17
Cumming	18.60	12.41	12.63	15.47	18.11	18.13	23.97
Dalton	17.40	11.41	8.63	14.47	16.91	13.53	21.77
Flowery Branch	18.60	12.41	12.63	15.47	18.11	18.13	23.97
Gainesville	18.80	12.91	17.53	15.77	18.71	18.93	24.37
Hazlehurst	20.30	15.41	15.83	16.77	22.51	22.93	26.57
Savannah	20.80	16.21	16.43	17.87	24.31	24.13	28.77
Valdosta	20.70	15.81	16.23	16.77	23.31	23.73	26.57

Most favorable rates (i.e. truck & carload minimums) used for computations.

Sources: Computed from rate data supplied by Atlantic Coast Line R. R. Co., Hoover Motor Express, Inc., Georgia Highway Express, Inc., and Georgia Port Authority

III. A Dehydrated Forage Industry

Since some of the persons who have expressed an interest in the potentials of a dehydrated forage industry are not familiar with the production process or the industry, an attempt is made here to outline the essentials.

Purpose of Dehydration

The nutritive values of forage crops, such as alfalfa and Coastal Bermuda, are most abundant when they are first cut; these values steadily decrease after harvesting due to oxidation. This is particularly true of the carotenoids, or pro-vitamin A.

> ...The field-curing process...may lead to the destruction of 45 to 90% of the carotene by enzymatic oxidation or destruction by light. The stability of carotene may be considerably enhanced by employing artificial drying, an effect which has been attributed to the inactivation of carotene oxidase (lipoxidase)...[1/]

As indicated, dehydration (rapid removal of water) of a fresh cutting of forage provides better retention of nutrients. In practice, midwestern processors of alfalfa transport a cutting immediately from the field to the dehydrator. Thus, it becomes possible to market dehydrated alfalfa meal with guaranteed high protein and Vitamin A content.[2/]

Processing

Field equipment usually includes a harvester-chopper and trucks for hauling the green material to the processing plant. There it is dumped into an automatic feeder which provides a uniform flow into the dehydrator drum. The chopped forage passes rapidly through an arrangement of three concentric shells (the drum), where it is subjected to dry, very hot air. Temperature and time of exposure must be carefully controlled to avoid charring. The dehydrated material then passes to a grinder (hammer mill) and turned into a meal. If the meal is to be pelleted, it passes through a pellet mill before cooling. Storage may be in bags or bulk.

1/ Irvin E. Liener, "Effect of Heat on Plant Proteins," Processed Plant Protein Foodstuffs, ed. Aaron M. Altschul (New York: Academic Press, Inc., 1958), p. 104.

2/ The most common guarantee for meal used in poultry feeds is 17% protein, 100,000 I.U. of Vitamin A, although smaller quantities of higher quality meal are available, and lower quality is available for other animal feeds.

There are many possible variations of detail, depending on whether additives are used and the type of product desired, e.g., fine meal for poultry feeds. The important point here is that a plant and equipment must be carefully engineered to meet specific requirements. A variety of equipment sizes and specifications is available.[3/]

Storage

Production of dehydrated Coastal Bermuda meal would, of course, be seasonal, as is that of alfalfa meal. Assurance of a year-round supply to consumers requires storage. Occasional fluctuations in quality of a cutting calls for storage facilities as well, to allow blending with other cuttings to obtain the proper guaranteed analysis of meal.

To prevent continued loss of nutritive value, the alfalfa meal industry has used special storage facilities. Since heat accelerates oxidation, refrigerated storage has been used extensively. A more effective but also more expensive method is inert gas storage, which cost (in 1954) $20 to $25 per ton of capacity, plus costs of gas generation.[4/]

Antioxidants

Much attention has been devoted to the possibility of developing a chemical antioxidant which could prevent loss of nutritive value and obviate the need for costly storage facilities. The major difficulty in such attempts is that most effective chemicals are toxic.[5/]

On February 12, 1959, the Food and Drug Administration announced approval of the use of Santoquin (an antioxidant made by Monsanto Chemical Company) in a number of dehydrated forage crops, including Coastal Bermuda, and poultry feeds.[6/]

According to data published in Feedstuffs,[7/] ground dehydrated alfalfa

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3/ More detailed descriptions of the production process may be found in "Alfalfa and Other Leaf Meals," by C. Ray Thompson, Processed Plant Proteins, p. 704-705, and Charles E. Reed, et al, Marketing Dehydrated Alfalfa, Marketing Research Report No. 254, U. S. Department of Agriculture and Kansas State College.

4/ Reed, p. 37

5/ Reed, p. 37

6/ "FDA Clears Santoquin for Poultry Feeds," Feedstuffs, XXXI, (February 14, 1959), p. 1.

7/ "Research Data Reported on Use of Santoquin in Forages," (March 14, 1959), 107, Fig. 3.

stored for 26 weeks at $90^{\circ}F$ will retain about 58 per cent of its carotene. Therefore, if the original content were as high as 173,000 units of Vitamin A, after six months of storage at 90° the meal would still contain approximately 100,000 units, assuming no change in the equivalence relation of carotene and Vitamin A. The economic importance of this antioxidant is obvious.

It does not necessarily follow that these same data are directly applicable to Coastal Bermuda meal; retention of carotene could be better or worse. Clearly, this is a worthy research project.[8/]

If the high cost of special storage facilities can be avoided, the likelihood of success of a dehydrated Coastal Bermuda meal industry in Georgia would be much improved.

Marketing

Presumably, the channels of distribution for Coastal Bermuda meal would be the same as those existing for alfalfa meal: (a) feed manufacturers, (b) brokers and commissionmen, (c) local livestock feeders, (d) mixed feed produced by the same management, and (e) other dehydrators and industries.[9/] The size and nature of the organization influence the distribution channel. Large scale feed lot operators could well afford to produce Coastal Bermuda meal for their own use, rather than the open market. In fact, at least one Georgia feed lot operator plans to start such an operation in the spring of 1959, and others have similar intentions for future production. However, the opportunity for commercial production and sale is the emphasis of this report.

8/ See Section VI, "Research in Progress."

9/ Reed, p. 54

IV. Alfalfa Versus Coastal Bermuda: Yields

The object of this section is two-fold. It is pointed out that (1) the southeastern states are at a natural disadvantage in alfalfa production, and (2) Coastal Bermuda is well adapted to this area, and, if adequate water is available, can produce yields per acre comparable to, if not better than, alfalfa grown under the most favorable conditions.

It should be added that no attempt is made to recommend optimum management practices. The data of this section are cited merely to support the statements above.

Alfalfa Yields

One of the primary reasons for the choice of alfalfa by the dehydrated forage industry is its relatively high yield. These yields vary widely, depending on the adaptability of soils and climate. As may be seen in Figure 1, the states most productive of dehydrated alfalfa are Colorado, Kansas, and Nebraska.

Published results of variety yield tests indicate that yields may approach 10 tons per acre (12% moisture basis) in sections of the Platte River Valley which are sub-irrigated.[1/] In other sections of Nebraska, yields per acre vary from two tons upward, the higher yields being obtained with irrigation.

No data was found to indicate a representative yield for the dehydration industry as a whole, but the industry is most extensively developed in areas producing high yields because of the time and cost considerations in transporting fresh cuttings to the dehydrators.

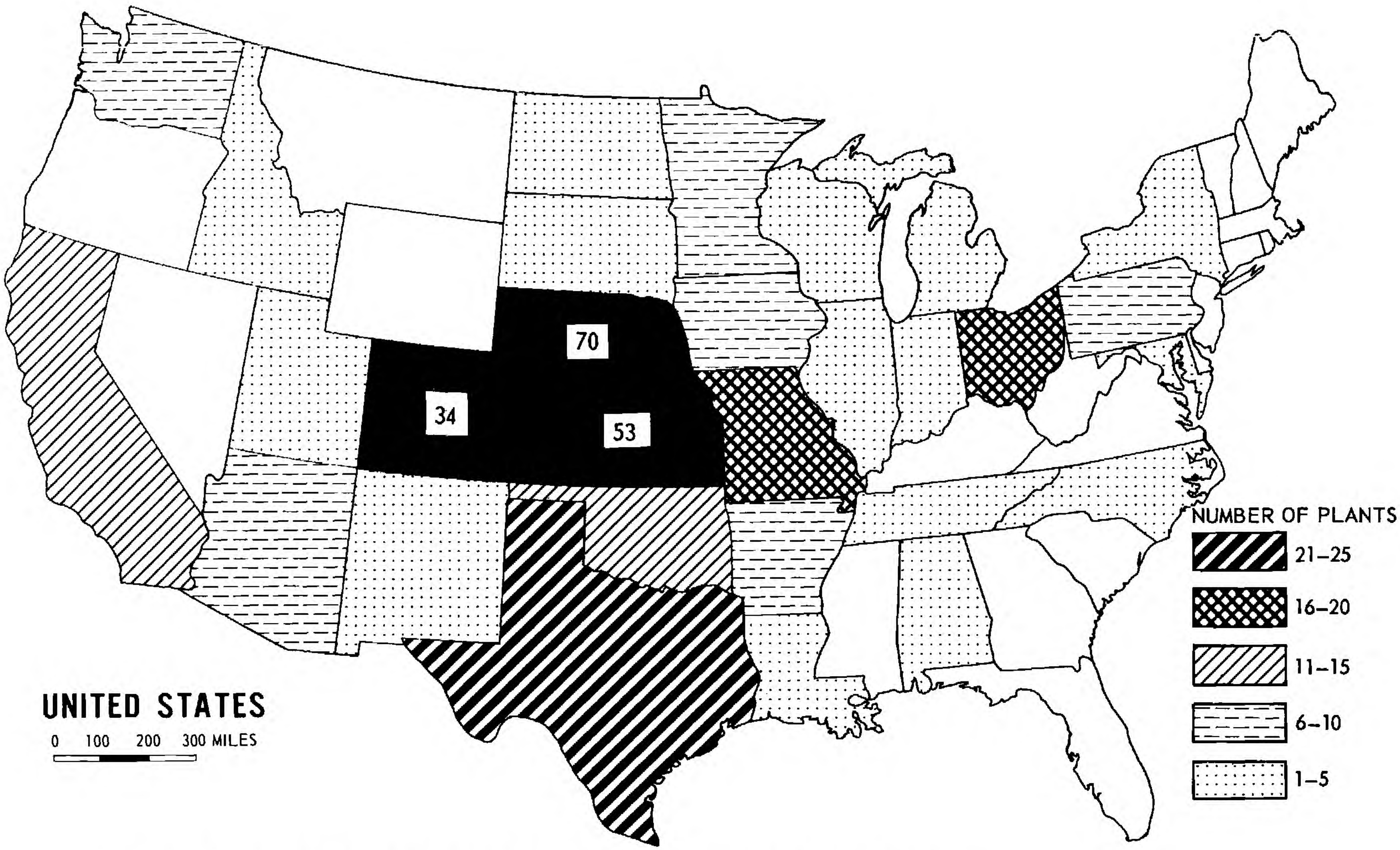
In contrast, "The soils in the Southeastern States and the Gulf Coast region, with few exceptions, are not naturally well suited to the production of alfalfa......"[2/] This statement is supported by a variety yield test at Experiment, Georgia, in which the highest yield obtained was under five tons per acre.[3/] (See Table 2.)

1/ W. R. Kehr, et al, Alfalfa Variety Yield Trials in Nebraska, Outstate Testing Circular 52, Nebraska Agricultural Experiment Station and U. S. Department of Agriculture (March 1956), p. 10-12.

2/ Growing Alfalfa, Farmers' Bulletin No. 1722, U. S. Department of Agriculture (Revised February 1954), p. 20.

3/ This should be compared with alfalfa yields under controlled conditions in Nebraska, not averages of states or the midwestern region.

FIGURE 1
DISTRIBUTION OF ALFALFA DEHYDRATING PLANTS, 1954



SOURCE: *Marketing Dehydrated Alfalfa, Marketing Research Report No. 254,* USDA and Kansas Agricultural Experiment Station

Table 2

ALFALFA VARIETY TEST - 1953-1955

Georgia Experiment Station
Experiment, Georgia

Variety	Hay Yields-Tons/A (oven dry basis) 1953	1954	1955	Average
Talent	3.00	3.08	4.84	3.64
N. C. Syn. B	2.41	3.77	4.60	3.59
Syn. A218	2.46	3.88	4.07	3.47
Pilca Butta	2.40	3.92	3.90	3.41
Grimm	2.63	3.07	4.43	3.38
Sevelra	2.75	3.14	4.15	3.35
Rhizoma	2.49	2.87	4.50	3.29
San Martin	2.76	3.65	3.42	3.28
N. C. Syn. A	2.21	3.09	4.14	3.15
Narragansett	2.40	3.11	3.78	3.10
Arizona Chilean	2.47	3.31	3.45	3.08
Syn. A225	2.26	3.05	3.78	3.03
Uruguay Cl. 10	2.30	3.21	3.54	3.02
Buffalo	1.90	2.73	4.28	2.97
Ranger	2.42	2.85	3.61	2.96
Friuli	2.23	2.89	3.63	2.92
Atlantic	2.05	2.91	3.58	2.85
Williamsburg	1.97	3.16	3.39	2.84
Caliverde	2.14	2.98	3.30	2.81
Kansas Common	1.96	2.98	3.42	2.79
Du Puits	1.64	3.03	3.10	2.59
Southwest Common	1.45	2.46	3.34	2.42
African	2.01	2.67	2.00	2.23
Nemastan	1.30	2.06	3.28	2.21
Nomad	1.11	1.88	1.95	1.65
LSD 5%	.15	.16	.12	.56
Rainfall - Inches	21.20	18.81	32.07	24.03

Date seeded: September 30, 1952
Size of plots: 3 × 17 feet, 3 rows, 1 ft. apart
Number of replications: Four
Fertilizer: 600 pounds 6-8-6 per acre
Lime: 1 ton/acre, harrowed in before planting
Dates of harvesting: 1953 - April 24 (data discarded on account of weeds), May 29, July 10, August 12.
1954 - April 30, June 22, August 5.
1955 - April 1, May 6, June 9, July 16, August 18.
Additional fertilizer applied as topdressing:
June 29, 1954 - 800 pounds 4-12-12 per acre
May 10, 1955 - 500 pounds 0-12-12 per acre

Source: Mimeographed Circular, publication date unknown.

In a test of alfalfa yield response to fertilization performed at Clemson,[4/] the highest rates of phosphorus and potassium applied produced a yield of 14,510 pounds per acre over a two year period (seven cuttings), or approximately 3.6 tons per acre per year. (See Table 3.)

Other references were found to cite yields in the Southeast of from two to five tons of hay per acre, without specifying hay moisture content or management practices.

Although the industry as a whole does not obtain the high yields mentioned in the Nebraska report, the fact remains that the southeastern and Gulf Coast states are not as suitable for alfalfa growth as the midwestern states, which have soil and climate advantages, plus instances of natural sub-irrigation or controlled flood irrigation.

Coastal Bermuda Yields

As shown in Figure 2, the area of adaptation for Coastal Bermuda grass is quite extensive--so extensive in fact that it is doubtful that true generalizations can be made as to quality and quantity of yields. Much of the agronomic research results found in a literature search is due directly or indirectly to Dr. Burton, who developed this hybrid grass at the Coastal Plain Experiment Station at Tifton, Georgia, and who has since extensively experimented in the area of management practices. Of the two major studies cited in this section, one was performed in the Coastal Plain region and the other in the Piedmont region, which together comprise most of the state.

Prine and Burton found that unusually high rates of nitrogen fertilization greatly increased yields of Coastal Bermuda grass. "The average hay yield at the 0 nitrogen rate was increased 6.7 times in 1953 (a very wet year) by the application of 900 pounds of N per acre. In 1954 (a very dry year), the 900-pound-N rate increased the 0 nitrogen rate yield 10 times."[5/] The averages mentioned here are taken over clipping frequencies ranging from 2 to 8 weeks. The individual data are more interesting than the average, as may be seen in Table 4. The highest yield obtained was 13.44 tons per acre (calculated at

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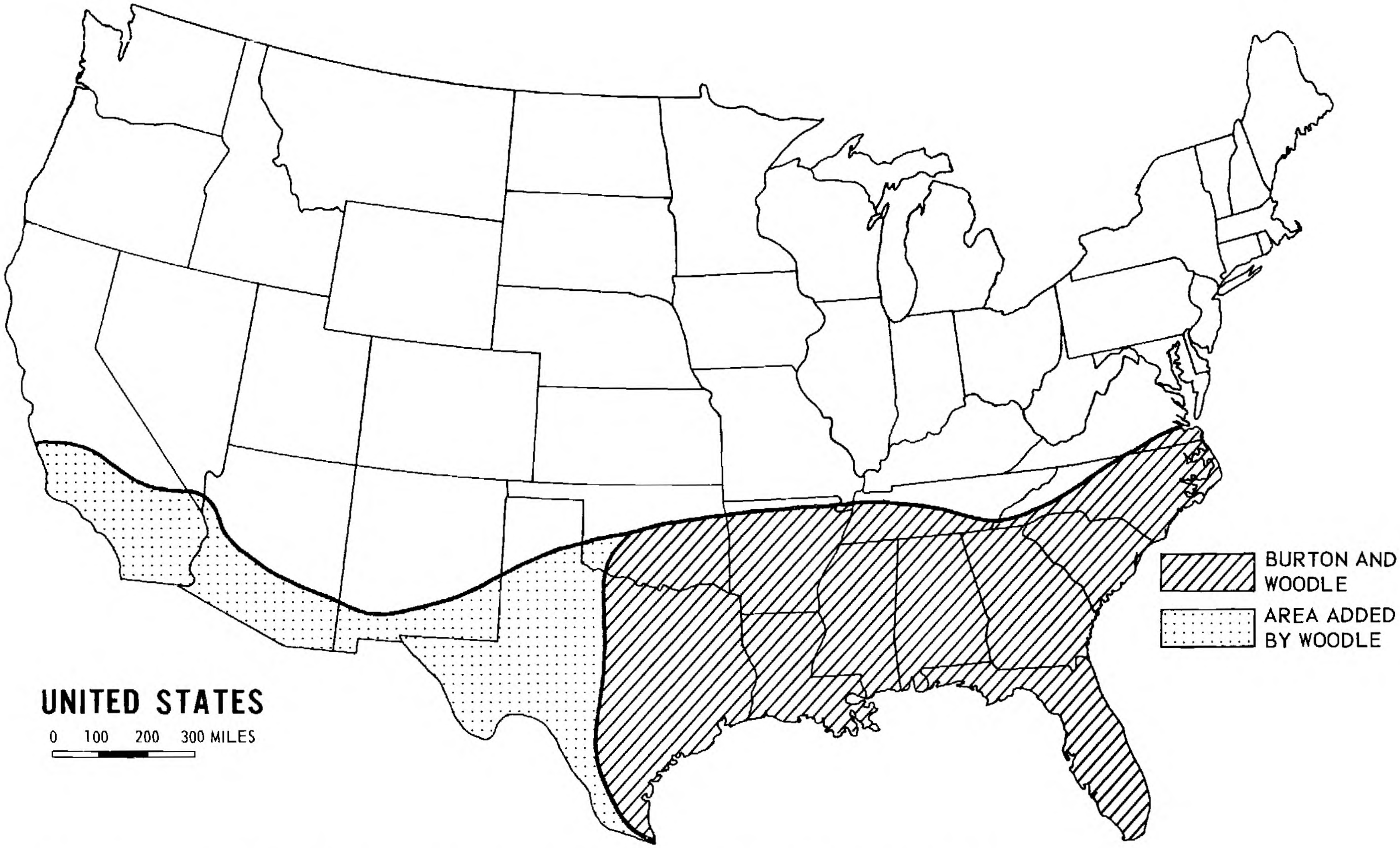
4/ Mack Drake and Ernest H. Stewart, "Alfalfa Fertility Investigations in South Carolina," Soil Science 69 (1950) 459-69. The variety tested was Kansas Common; yields were calculated at 15% moisture.

5/ Gordon M. Prine and Glenn W. Burton, "The Effect of Nitrogen Rate and Clipping Frequency Upon the Yield, Protein Content and Certain Morphological Characteristics of Coastal Bermuda grass (Cynodon dactylong, (L) Pers)," Agronomy Journal 48 (1956): p. 298.

-15-

FIGURE 2
AREA ADAPTED TO COASTAL BERMUDA



SOURCES: Glenn W. Burton, *Coastal Bermuda Grass*, Coastal Plain Experiment Station, Tifton, Georgia, Bulletin N.S. 2, Sept. 1954
Hugh A. Woodle, *Coastal Bermuda Grass for Grazing, Hay and Silage*, Clemson Agricultural College, Clemson, S.C., Circ. 406, Rev. 6–58

Table 3

EFFECT OF RATE AND PLACEMENT OF FERTILIZER ON YIELD OF ALFALFA
FERTILIZER TREATMENTS AND YIELDS IN POUNDS PER ACRE

Initial Fertilizer Applications			Yield of Hay, Seven Cuttings, With Maintenance Fertilizer Applied After First Cutting					
Surface		Plow Sole	K_2O	K_2O	K_2O	Av. K_2O	P_2O_5 K_2O	Treatment
P_2O_5	K_2O	P_2O_5	0	60	120	(0, 60, 120)	180 120	Replications
0	0	0	9,660	9,130	9,340	9,380	11,020	6
0	0	180	12,400	12,120	12,340	12,290	12,140	3
180	0	0	10,820	11,040	11,170	11,010	11,130	6
180	0	180	10,730	12,990	12,170	11,970	12,520	3
0	200	0	10,200	10,450	10,560	10,410	10,950	6
0	200	180	12,840	11,930	12,670	12,480	12,370	3
180	200	0	10,880	11,400	11,340	11,200	12,050	6
180	200	180	14,100	14,070	13,930	14,030	14,510	3

Basic fertilizer treatment applied to all plots as follows: 5,000 pounds dolomite disked into surface 4 inches of soil; 20 pounds borax; 400 pounds 4-10-6 drilled 3 inches deep, rows 7 inches apart.

Source: Mack Drake and Ernest H. Stewart, "Alfalfa Fertility Investigations in South Carolina," Table 4, Soil Science, Volume 69 (1950), p. 464.

Table 4

THE EFFECT OF NITROGEN RATE AND CLIPPING FREQUENCY ON THE HAY PRODUCTION OF COASTAL BERMUDA GRASS DURING A 24-WEEK PERIOD IN A WET SEASON (1953) AND A DRY SEASON (1954)

	Tons of Hay Produced by Following Pounds of Nitrogen Per Acre[1]											
	0		100		300		600		900		Average	
Clipped every	1953	1954	1953	1954	1953	1954	1953	1954	1953	1954	1953	1954
Week[2]	--	--	--	--	--	--	6.25	2.38	--	--	--	--
2 Weeks	1.04	0.34	2.66	1.20	5.25	3.05	7.78	3.50	8.80	3.85	5.11	2.39
3 Weeks	1.49	.42	3.98	1.63	6.09	3.30	8.59	4.42	9.14	4.46	5.86	2.85
4 Weeks	1.21	.48	4.40	2.03	7.88	4.22	9.68	4.97	10.54	5.13	6.74	3.37
6 Weeks	1.94	.58	5.70	2.75	9.73	5.18	12.55	6.06	13.44	6.13	8.67	4.18
8 Weeks	2.52	.86	6.10	2.88	9.99	5.46	12.47	7.08	13.08	7.24	8.83	4.70
Average	1.64	.54	4.57	2.10	7.79	4.24	10.21	5.21	11.00	5.40	7.04	3.50

5% L.S.D. for nitrogen-level and clipping-frequency averages for 1953 and 1954 are 0.25 and 0.22, respectively.

5% L.S.D. for single nitrogen-level clipping-frequency values for 1953 and 1954 are 0.57 and 0.51, respectively.

1/ Hay adjusted to contain 16% moisture.

2/ Weekly values not included in averages.

Rainfall from April 1 to November 1, 1953 and 1954, was 39.66 inches and 13.68 inches, respectively.

Source: Gordon M. Prine and Glenn W. Burton, "The Effect of Nitrogen Rate and Clipping Frequency Upon the Yield, Protein Content and Certain Morphological Characteristics of Coastal Bermudagrass (Cynodon dactylon, (L) Pers.). Agronomy Journal 48 (1956): p. 297.

15% moisture), but it should be emphasized that this was obtained in an unusually wet season. The advantages of irrigation are obvious.

"The range in crude protein from 8.46% to 25.43% in 1954 demonstrates the striking effect of clipping frequency...upon the protein content of Coastal Bermuda grass hay."[6/] The detail of these effects is reproduced in Table 5.

The data on yields obtained with a six-week clipping frequency are graphed in Figure 3.

Adams and Stelly in a study of yield response to fertilization did not apply nitrogen at levels higher than 400 pounds per acre, but it will be noted that yield responses were still increasing up to the maximum rate applied. (See Table 6.) Of course, these data are not directly comparable since the rates of phosphate and potassium were also varied in this study, whereas the former study varied only nitrogen level. Among their conclusions is that "Coastal Bermuda grass appears to utilize water more efficiently than does common...the rainfall requirements per ton of grass forage of Coastal and common Bermuda grasses were 2.6 and 4.0 inches, respectively."[7/] The data of Burton and Prine suggest that rainfall requirements may be even less; both studies agree that Coastal Bermuda is drought resistant.

Since the levels of nitrogen fertilization that are necessary to obtain maximum yields are unusually high, the question of other effects is immediately raised. It is noted by Prine and Burton that "The highest nitrate concentrations were well below the arbitrary value of 1.5% KNO_3 content designated by Bradley, et al[8/]...as the dividing line between toxic and non-toxic forage."

In two subsequent investigations, Burton and others found that"....the palatability of Coastal Bermuda grass was improved substantially by nitrogen fertilization. There was no evidence to indicate that annual rates up to

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6/ Ibid.

7/ William E. Adams and Matthias Stelly, "A Comparison of Coastal and Common Bermudagrasses (Cynodon dactylon (L) Pers.) in the Piedmont Region: I. Yield Response to Fertilization," Agronomy Journal 50 (1958): pp. 457-9.

8/ Citation is: "Bradley, W. B., Eppson, H. F., and Beath, O. A. Livestock poisoning by oat hay and other plants containing nitrate, Wyoming Agr. Exp. Sta. Bul. 241: 1-20, 1940."

Table 5

THE EFFECT OF NITROGEN RATE AND CLIPPING FREQUENCY ON THE CRUDE PROTEIN PERCENTAGE OF OVEN-DRY COASTAL BERMUDAGRASS DURING A 24-WEEK PERIOD IN A WET YEAR (1953) AND A DRY YEAR (1954)

Percent Protein From Following Pounds of N Per Acre:

	0		100		300		600		900		Average	
Clipped every	1953	1954	1953	1954	1953	1954	1953	1954	1953	1954	1953	1954
Week[1/]	--	--	--	--	--	--	21.40	25.43	--	--	--	--
2 Weeks	9.98	14.15	13.60	16.24	17.39	20.53	20.85	23.86	22.86	23.17	16.94	19.59
3 Weeks	9.65	10.01	12.89	12.83	16.60	17.59	18.80	18.57	20.83	22.78	15.75	16.36
4 Weeks	9.25	10.95	11.19	10.96	15.23	15.44	16.98	18.13	19.56	18.70	14.44	14.84
6 Weeks	7.58	10.27	7.76	9.31	11.28	14.09	13.83	13.51	15.34	17.26	11.16	12.89
8 Weeks	6.88	8.46	8.44	9.71	10.36	11.37	12.20	12.79	13.33	16.04	10.24	11.67
Average	8.67	10.77	10.78	11.81	14.17	15.80	16.53	17.37	18.38	19.59	13.71	15.07

1/ Not included in the average.

5% L.S.D. for nitrogen-level and clipping-frequency averages in 1953 and 1954 are 0.23 and 0.61, respectively.

5% L.S.D. for single nitrogen-level clipping-frequency values in 1953 and 1954 are 0.52 and 1.37, respectively.

Source: Gordon M. Prine and Glenn W. Burton, "The Effect of Nitrogen Rate and Clippings Frequency Upon the Yield, Protein Content and Certain Morphological Characteristics of Coastal Bermudagrass (Cynodon dactylon, (L) Pers.). Agronomy Journal 48 (1956): p. 298

FIGURE 3
HAY YIELD RESPONSE TO NITROGEN FERTILIZATION
(Clippings at Six-Week Intervals)

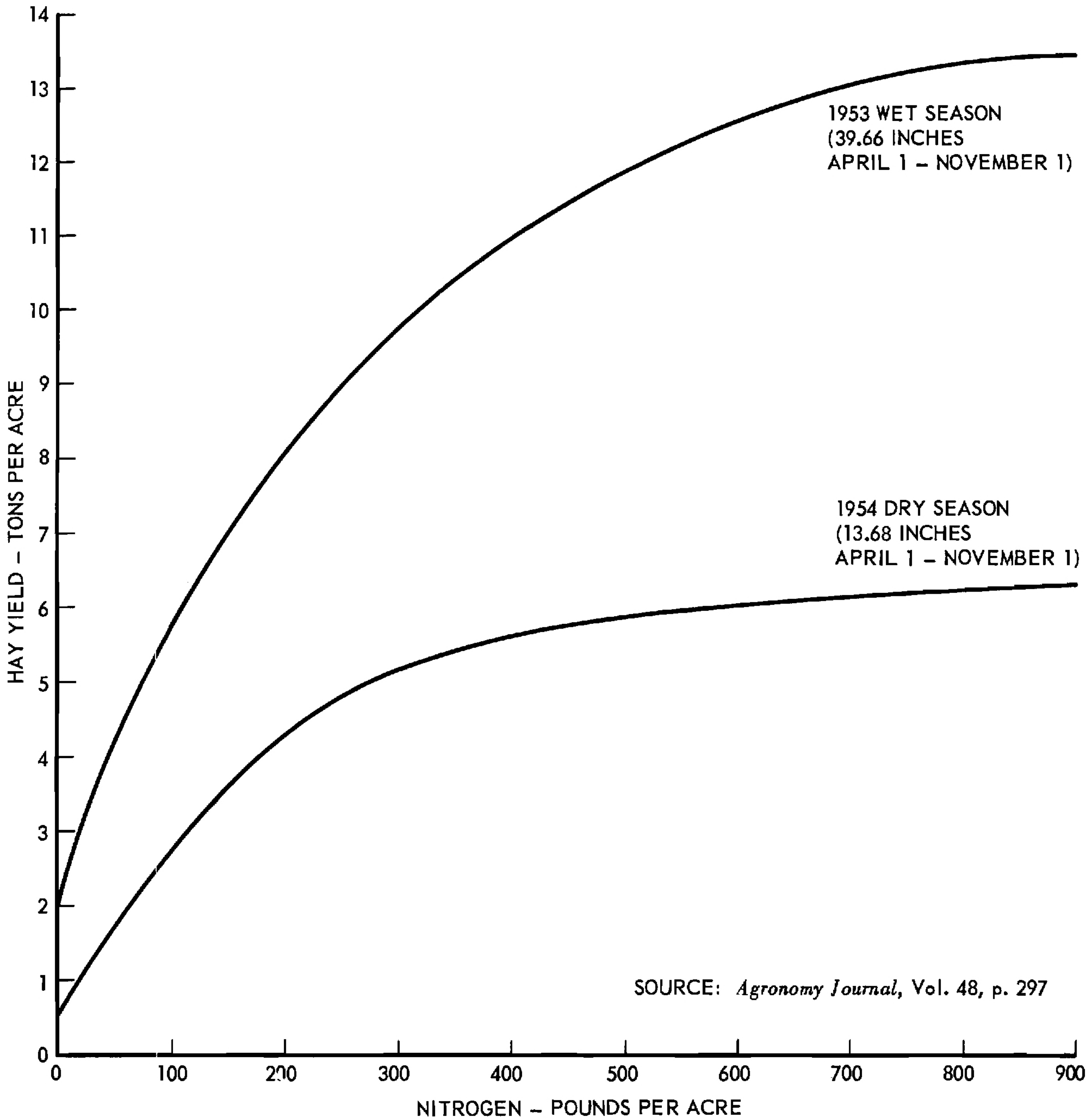

Table 6

COMPARISON OF YIELDS OF COASTAL AND COMMON BERMUDAGRASSES GROWN WITH AND WITHOUT CRIMSON CLOVER AT VARIOUS FERTILIZER LEVELS. 2-YEAR AVERAGE, 1955-1956

			Yield Oven-Dry Forage					
			Common Bermudagrass Plots			Coastal Bermudagrass Plots		
N	P_2O_5	K_2O		Grass and Clover			Grass and Clover	
lb./A	lb./A	lb./A	Grass (no clover)	Grass only	Grass + Clover	Grass (no clover)	Grass only	Grass + Clover
			T/A	T/A	T/A	T/A	T/A	T/A
0	0	0	1.04	1.56	3.04	1.67	2.21	3.42
0	100	100	1.30	1.61	3.25	1.92	2.62	4.02
50	0	0	1.67	1.83	3.27	2.69	3.13	4.32
50	50	50	1.69	2.24	3.84	3.22	3.65	5.22
100	50	50	2.37	2.78	4.53	3.98	4.16	5.58
200	50	50	3.32	3.45	5.13	5.76	4.96	6.37
200	100	100	3.69	3.64	5.26	5.47	5.62	7.02
400	0	0	3.66	3.15	4.45	5.56	5.07	5.95
400	100	100	4.48	3.81	5.28	6.63	6.24	7.58
400	200	200	4.61	4.33	5.64	7.15	7.33	8.48
	Average		2.78	2.84	4.37	4.40	4.50	5.79
	LSD	5%	0.25	0.14	0.21	0.25	0.14	0.21
		1%	0.33	0.19	0.29	0.33	0.19	0.29

Source: William E. Adams and Matthias Stelly, "A Comparison of Coastal and Common Bermudagrasses (Cynodon dactylon (L) Pers.) in the Piedmont Region: I. Yield Response to Fertilization." Agronomy Journal 50 (1958): p. 457.

1,500 pounds of nitrogen per acre decreased the palatability of this grass,"9/ and that "...nitrogen source did not affect the palatability of Coastal Bermuda grass......it may be concluded that any one of the four nitrogen sources compared in this study will be as effective as any other in increasing the palatability of Coastal Bermuda grass."10/

Pertinent data from these two experiments are given in Tables 7 and 8.

Since so much emphasis has been placed on nitrogen fertilization, perhaps it should also be mentioned that other nutrients must be added for optimum yields. As might be expected, the large yields resulting from heavy nitrogen fertilization tend to deplete other essential elements from the soil, and these must be systematically replaced. For example, "...the soils in this region (Coastal Plain) are, generally speaking, deficient in this element (potassium) and require from one-half to two-thirds as much applied K_2O as nitrogen in order to maintain optimum production of Coastal Bermudagrass."11/

9/ Glenn W. Burton, et al, "The Palatability of Coastal Bermudagrass (Cynodon dactylon (L) Pers.) as Influenced by Nitrogen Level and Age," Agronomy Journal 48 (1956): pp. 360-362.

10/ Glen W. Burton, James E. Jackson, and B. L. Southwell, "Does Nitrogen Source Affect the Palatability of Coastal Bermudagrass?", Agronomy Journal 50 (1958): p. 172.

11/ James E. Jackson and Glenn W. Burton, "An Evaluation of Granite Meal as a Source of Potassium for Coastal Bermudagrass, "Agronomy Journal 50 (1958): p. 307.

Table 7

THE EFFECT OF NITROGEN LEVEL UPON THE PALATABILITY OF COASTAL BERMUDAGRASS AS MEASURED BY CATTLE GIVEN FREE CHOICE OF ALL TREATMENTS IN 1955

N level1/	Percent of Forage Consumed On:				
	May 26 2/	July 6 2/	Aug. 3 2/	Sept. 6 3/	Oct. 25 4/
lbs./A	%	%	%	%	%
0	21	25	4	77	12
50	23	33	13	74	26
100	38	24	15	80	16
200	40	30	32	74	20
300	45	36	31	76	38
400	49	34	31	75	33
600	49	48	38	77	33
900	48	45	31	82	50
1,200	57	46	28	84	51
1,500	56	49	31	76	53
5% LSD	12	15	11.5	NS	25

1/ Nitrogen applied March 17 and July 14. P and K were adequate.

2/ Grazed 2 hours by herd of 20 Hereford cows and calves.

3/ Grazed 4 days by 3 Jersey cows until all plots were grazed closely.

4/ Grazed 2 days by 1 Jersey cow.

Source: Glenn W. Burton et al, "The Palatability of Coastal Bermuda Grass (Cynodon dactylon (L) Pers.) as Influenced by Nitrogen Level and Age," Agronomy Journal 48 (1956): pp 360-362.

Table 8

THE EFFECT OF NITROGEN SOURCE UPON THE PALATABILITY OF COASTAL BERMUDAGRASS AS MEASURED BY A HERD OF HEREFORD CATTLE GIVEN FREE CHOICE OF ALL MATERIAL IN 1956.

Source of Nitrogen	Per cent forage consumed on:				
	May 10	June 28	July 27	Sept.21	Average
Amonium nitrate	39.9	27.0	22.8	22.1	27.9
Sodium nitrate	38.2	21.0	23.7	17.6	25.1
Sulfate of amonia	40.7	23.4	20.2	24.8	27.3
Urea	36.6	25.9	23.4	20.1	26.5

Palatability measurements were made as follows: On May 10, June 28, July 27, and Sept. 21, a 26-inch strip was cut through one side of each plot and the forage removed was weighed and recorded. Approximately 20 Hereford cows and calves were then turned into the area and allowed to graze the remaining forage. When about a third of the forage had been consumed, the animals were removed (usually some two hours after they were turned into the area) and another 26-inch strip adjacent to the first strip was cut and weighed. The difference between the first and second yields expressed in per cent of the first gave the per cent of the forage consumed and was considered an index of the palatability of the plot in question. All data were then subjected to statistical analyses.

These data show that nitrogen source did not affect the palatability of Coastal Bermudagrass as measured by this technique. Neither were the rate X source interactions significant. Nitrogen rate, as in the earlier study, did influence the palatability of Coastal Bermudagrass, the consumption increasing as the rate of nitrogen increased. Thus, it may be concluded that any one of the four nitrogen sources compared in this study will be as effective as any other in increasing the palatability of Coastal Bermudagrass.

Source: Glenn W. Burton, James E. Jackson, and B. L. Southwell, "Does Nitrogen Source Affect the Palatability of Coastal Bermudagrass?" Agronomy Journal 50 (1958): p. 172.

V. Alfalfa Versus Coastal Bermuda: Nutritive Value

Generally, there are two methods of appraising the nutritive value of forages: chemical analysis and feeding trials. One of the major functions of chemical analysis is its aid in understanding the contribution of a particular component included in a feed. Due to the complexity of the interactions among the various components of a feed, analysis alone has limited value as a predictive tool. In other words, the ultimate test of nutritive value must be the results obtained from actual feeding trials, conducted with appropriate controls.

A comprehensive analysis of Coastal Bermuda has not yet been made. In the comparative table of this section, many nutrients which are known to be present in alfalfa are omitted, simply because the extent of their presence in Coastal Bermuda is unknown.

Chemical Analysis

The data relating to Coastal Bermuda in Table 9 were obtained from samples grown at the Coastal Plain Experiment Station, Tifton, Georgia. In a previous publication,[1/] the stands were described as "heavily fertilized," but the yield response to higher fertilization observed in Section IV makes that description equivocal. The stands were heavily fertilized relative to the levels usually employed for forage crops, not necessarily relative to the levels required for optimum yields of Coastal Bermuda. In other words, the analysis of those samples may not be representative of Coastal Bermuda produced under optimum management practices. In making the comparison, it should be noted that the values for alfalfa are described as "average;" they are not representative of high quality dehydrated meal.

In commenting on the analysis of Coastal Bermuda, Burton has written:

> Our main objective in this research was to ascertain if we could produce a meal from Coastal Bermuda grass that could be substituted for alfalfa meal in rations for various classes of livestock. The chemical analysis of the meal produced at Tifton in 1958 indicates that we can produce a meal from Coastal Bermuda that will equal, or surpass, the average alfalfa meal in Vitamin A content, which we understand is the main ingredient sought by feed manufacturers who use alfalfa

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1/ Glenn W. Burton and E. M. Parker, "Chemical Constituents Including Certain Vitamins and Amino Acids Found in Heavily-fertilized Coastal Bermuda Meal," Georgia Agronomy Abstracts, Twelfth Annual Meeting, U. of Georgia, Athens.

Table 9

CHEMICAL CONSTITUENTS INCLUDING CERTAIN VITAMINS AND AMINO ACIDS FOUND IN HEAVILY-FERTILIZED COASTAL BERMUDA MEAL

Constituent	Dehydrated Coastal Bermuda Meal Harvested On					Average Dehydrated Alfalfa Meals
	May 5 1/	June 1 2/	June 30	Aug. 25	Average	
Vitamin A units/lb.	230,000	107,700	77,800	113,000	132,250	80,000
Vitamin B-12 mgs./lb.	.0038	.0039	.0009	.0030	.0029	Present
Riboflavin, mgs./lb.	4.88	5.06	3.44	3.33	4.18	6.75
Niacin, mgs./lb.	37.8	30.9	28.4	26.3	30.8	13.00
Pantothenic acid, mgs./lb.	9.00	5.30	4.69	7.08	6.52	15.40
Choline, mgs./lb.	675	540	436	546	549	462
Crude Protein, %	22.61	17.16	13.56	16.50	17.46	17.80
Ether extract, %	3.15	2.90	1.95	2.24	2.56	2.50
Ash, %	6.69	6.20	5.89	4.99	5.94	-
Moisture, %	5.37	5.71	8.22	6.28	6.30	9.5
Fiber, %	27.10	27.72	38.40	28.40	30.40	24.2
Carbohydrate, %	35.08	40.31	31.98	41.59	37.24	39.7
Calories/lb. (minus fiber)	1,160	1,150	908	1,134	1,088	-
Calories/lb. (plus fiber)	1,655	1,650	1,602	1,664	1,642	-
Tryptophane, %	.322	.271	.180	.238	.253	0.33
Arginine, %	1.004	.915	.708	.669	.824	0.85
Methionine, %	.226	.223	.240	.176	.216	0.31
Cystine, %	.097	.080	.062	.082	.080	0.31
Lysine, %	1.314	.870	.748	.897	.957	0.85

Received 400 lbs. of N and 1000 lbs. of 0-10-20 per acre 3-29-58 and 100 lbs. of N/A. 6-30-58. Yields (lbs. dry matter per acre) for May 5, June 1, June 30, July 28, August 25, and November 17 were 3051, 3337, 3813, 2650, 1435, and 1377, respectively. The army worms took at least 1/3 of the July 28 yield and drought greatly reduced later yields.

Chemical analyses by Wisconsin Alumni Research Foundation Biochemical Laboratory, Madison, Wisconsin.

Source: Glenn W. Burton and E. M. Parker, "Chemical Constituents Including Certain Vitamins and Amino Acids Found in Heavily-fertilized Coastal Bermuda Meal," Georgia Agronomy Abstracts, Twelfth Annual Meeting, University of Georgia, Athens.

1/ Sample #1

2/ Sample #2

meal. Our experience during the summer of 1958 indicates that Vitamin A content will be influenced by the rate of nitrogen fertilization and the age of the grass when it is cut. While we need more research on this problem it appears that the grass should be cut at 28-day intervals in the spring and early fall and should probably be cut more frequently, perhaps at 24- to 25-day intervals in mid-summer in order to get high-quality meal that will not exceed alfalfa meal in fiber content.

The meal produced at Tifton in the summer of 1958 came from a well-established sod of Coastal Bermuda that received 500 pounds of nitrogen and 1000 pounds of 0-10-20 per acre. The average of the analyses made in 1958 showed Coastal Bermuda meal to be higher than average alfalfa meal in Vitamin A, Vitamin B-12, niacin, choline, fiber, cystine, and lysine. The higher average fiber content was due to one mid-summer sample that contained considerably more fiber than the other samples. It is believed that this fiber content could be reduced materially by cutting the grass more frequently. Average Coastal Bermuda meal was equal to alfalfa meal in crude protein, ether extract, carbohydrate, and argenine and was lower in riboflavin, pantothenic acid, tryptophane, and methionine.2/

The lack of conclusiveness in chemical analyses is emphasized in each of the following comments, taken from private communications:

....these analyses do not differ greatly from mean values for alfalfa meal, and thus, on the basis of this information alone, one would say that it would be of similar value as animal feed. Obviously, if the availability to the animal of any of the important nutrients were less than is true in the case of alfalfa meal, the value of your material would be less. This can only be determined by *in vivo* trials." --Paul E. Johnson, Executive Secretary, Food Protection Committee, National Academy of Sciences, National Research Council.

On the basis of the values for crude protein and crude fiber that you gave for Samples 1 and 2, I calculated the total digestive nutrients (TDN) which expresses their feeding value for ruminants. These values are 67.1 and 64.0%, on the dry matter basis, for Samples 1 and 2, respectively. In other words, 100 pounds of dry matter of each forage contains 67.1 and 64.0 pounds of TDN. We would classify No. 1 as "excellent" and No. 2 as "high good" with regard to their quality and the total feeding value which they contain.

I checked with our poultry nutritionist, Dr. R. V. Boucher, as to how the above samples of forage might be evaluated in terms of their feeding value for poultry. He was of the opinion that your forages compared favorably with alfalfa meal guaranteed to contain 17% crude protein. They are very similar in their amino acid composition with the exception of cystine of which they contain only about one-fourth as much as the alfalfa meal.

2/ Private communication.

In order to determine accurately the feeding value of your two forages for ruminants and poultry, they would have to be fed in well controlled feeding experiments.--John W. Bratzler, Pennsylvania State University.

Your analyses looked good and it looks like your forage might be a substitute for alfalfa meal. However, the analyses of any feed is only one indication of the potentials of that feed. The final criteria is an animal test to determine how well the animal responds to the feeds. Thus, your forage would have possibilities for both swine and poultry feeding. There is also considerable interest now in the use of alfalfa meal for cattle and for sheep and so your forage would also have a potential as a substitute for alfalfa with these two classes of livestock. It would also have value for dairy cattle as a substitute for alfalfa. In other words, the only way you can find out the possibilities for your dehydrated forage is by using it in rations for livestock and poultry as a substitute for alfalfa."--T. J. Cunha, Head of the Department of Animal Husbandry and Nutrition, University of Florida.

This is to give you my evaluation of the forages...for dairy cattle.

Each of the forages sampled would provide an excess of Vitamin A activity. Riboflavin, niacin, pantothenic acid, tryptophane, arginine, methionine, cystine and lysine requirements of cattle have not been established. Indications are that with normal rumen fermentation, microbial synthesis provides all of the water soluble vitamins needed. No specific amino acid deficiency has been reported in cattle. Also, we know that rumen microflora are able to synthesize amino acids from simple nitrogenous compounds such as ammonia.

The protein contents of the forage samples are adequate for growth or milk production assuming coefficients of digestibility of at least 50%.

The crude fiber content of the May 5, June 1, and August 25 cuttings of Coastal Bermudagrass are about equal to that of alfalfa hay averaging 51% TDN. Therefore, the forages could not be rated more than average based on crude fiber content.

The carbohydrate value is rather meaningless as it was determined by difference rather than actual analyses. It is possible that forage no. 2 would be more palatable than no. 1 due to higher sugar content. But this would depend on the forage species involved.

Ether extract is only another source of energy. These forages are about average for this component.

The ash content of the forages doesn't tell much. Analysis for individual elements is needed for a good evaluation. I prefer that forages contain 8-10% ash. This increases the likelihood that Ca and P contents will be adequate.

I am sure that you realize that the relationship between chemical composition and nutritive value may be very low. For this reason, the adequacy of these forages for ruminants may be entirely different from my interpretations."--G. E. Hawkins, Dairy Husbandry Department, Alabama Polytechnic Institute.

For ruminants we need to be concerned only about carotene. Since mature cows need daily about 3,000 I.U. of Vitamin A per 100 pounds of live weight, a 1,000 pound cow would receive amply Vitamin A activity from only a fraction of a pound of the test forages. Good quality, dehydrated alfalfa meal contains only about 200,000 I.U. of Vitamin A activity per pound.

Cattle are not benefited by water-soluble vitamins furnished in feeds. Non-ruminants, of course, need a dietary source of these vitamins. Based on the chemical data supplied, the test forages would supply the daily requirements of niacin, riboflavin and B_{12} for a 50 pound pig when consumed daily in the following amounts (pounds), 0.40, 0.55 and 3.53, respectively...

Beef cattle (all ages other than nursing calves) need to be fed rations containing approximately 12-13 per cent crude protein (exception in the case of L. Sericea). In most instances, cattle rations are formulated on the basis of crude protein....it is recommended that rations contain 5-6 per cent of digestible protein. The digestibility of the protein in our summer grasses is somewhere in the range of 55 to 65 per cent. Therefore, the protein content of the forage samples analyzed by the Wisconsin Alumni Research Laboratories would be more than adequate for supplying the protein needs of cattle consuming these forages as the sole source of nutriment. Also, should hay containing as much protein as these samples be available for mixing with fattening rations for cattle, it would not be necessary to include a high-protein oil meal in the mixture.

...You will note that the data supplied on the test forages compare quite favorably with average composition information on alfalfa meal (dehydrated).

Since the mineral data furnished on the test forages are relative only to ash content, the nutritive value of the forages with respect to minerals cannot be evaluated....

The fiber contents of the test samples are about equivalent to the values we obtain for various pasture herbages (grasses). It might be informative to note that the guaranteed analysis for alfalfa leaf meal is not more than 18 per cent Crude Fiber. In other words, the fiber contents of the test samples are too high for presently accepted standards regarding forage products for use in manufactured feeds....--W. B. Anthony, Animal Husbandry Department, Alabama Polytechnic Institute.

References to samples one and two relate to the analyses of the May 5 and June 1 cuttings, displayed in Table 9.

These opinions have been included as partial evidence of the value of Coastal Bermuda, not as being conclusive. They also indicate a need for further analysis.

Feeding Trials

The University of Georgia, Clemson Agricultural College, and North Carolina State College have published results of feeding trials using Coastal Bermuda as a feed ingredient.

The data from some of these trials are included. The summaries and conclusions are grouped according to the type of animals fed.

Poultry

A ten week test during the winter of 1957 on broiler chicks indicated that Coastal Bermuda could be effectively substituted for alfalfa meal in broiler rations. E. W. Glazener, head of the Poultry Science Department, N. C. State College, concluded:

> The use of dehydrated Coastal Bermuda grass and Sericea Lespedeza as substitutes for dehydrated alfalfa meal in poultry feeds has been studied. These studies were based on the premise that alfalfa meal is used mostly for its Vitamin A content. Therefore, diets were made up deficient in Vitamin A by using white corn meal instead of yellow. Levels of alfalfa meal and Coastal Bermuda and Lespedeza were then added to these feeds. Both the dehydrated Bermuda and Lespedeza were equal to or superior to the alfalfa sample used at all levels fed. A level of 10% of either showed no greater depressing effect on the growth of the chicks than the same level of alfalfa.[1/]

After a test comparing these forages in turkey feeds, Glazener reported, "....we have reached the conclusion that quality for quality, either Coastal Bermuda or Sericea Lespedeza may be substituted for alfalfa as a source of Vitamin A in poultry feeds."[2/] (Table 10.)

Cattle

A 100-day trial at the Southeast Georgia Branch Experiment Station, Midville, Georgia, in 1958, compared alfalfa and Coastal Bermuda in pellet form.

> The data show that feeding beef steers pelleted Coastal Bermudagrass was equivalent to similarly treated high quality alfalfa. Not only were daily gains equal but feed consumption and conversion ratios were almost identical. Results of a number of experiments conducted in Georgia and other states have shown that steers gained from 1.00

1/ "A New Agricultural Industry for the South is Born!," Booklet published in 1958 by McNair's Yield Tested Seed Co., Inc., Laurinburg, North Carolina.

2/ Ibid.

Table 10-A

BROILER FEEDING TRIAL

Supplement	10 Wks. Wt.	% Mortality	Feed Conversion
None	---	100.0	---
3% Alfalfa	3.21	15.5	3.23
3% Coastal Bermuda	3.42	6.0	2.80
3% Sericea Lespedeza	3.37	6.5	2.86

Table 10-B

TURKEY FEEDING TRIAL

Ration	Avg. Wt. Per Bird (Lbs.)	Feed Conversion	Feed Cost Per Lb. Gained
Feed No. 1--Basal	7.094	2.88	13.75
Feed No. 2--3.75% Alfalfa	6.611	3.02	14.38
Feed No. 3--3.75% Sericea	6.927	3.01	14.34
Feed No. 4--3.75% Coastal	7.320	3.03	14.38

These data are performance results at the end of 10-week trials.

Source: "A New Agricultural Industry for the South is Born!", published by McNair's Yield-Tested Seed Co., Inc.

to 1.25 pounds daily when grazed on Coastal Bermudagrass in the usual manner. In this experiment, pelleted Coastal Bermudagrass produced approximately 80% more daily gain than would have been expected from conventional grazing.

It should be emphasized that these data are preliminary since they represent the results of only one experiment.3/

Work just completed at Tifton includes a study of concentrate-roughage mixtures, and the effect of pelleting these mixtures. No data have yet been published, but it is understood that unpelleted feeds were more effective when a high ratio of concentrate to roughage was used. When the mixtures were pelleted the reverse was true--greater daily gains were obtained with higher ratios of roughage to concentrate.

Another experiment, conducted during the past winter (1958-59) at Athens, compared the efficiency of various forms of Coastal Bermuda hays in a winter ration for calves. Preliminary results are summarized in Table 11.4/ Perhaps one of the most significant results of this experiment is the footnote reference to the effect that calves found Coastal Bermuda pellets more palatable than cottonseed meal. (See Section IV for effects of nitrogen on palatability of Coastal Bermuda.)

Swine

An experiment was conducted by North Carolina State College to evaluate alfalfa, Coastal Bermuda, and Sericea Lespedeza as sources of carotene for growing pigs. The conclusion was that "There was no marked difference in gains produced by alfalfa versus the other forages when compared at either 3 or 10% of the ration."5/ (Table 12.)

A comparison of gains produced by dehydrated alfalfa meal and dehydrated Coastal Bermuda meal was given in a preliminary report published by Clemson,

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3/ "A Progress Report," mimeographed, 1958. Southeast Georgia Branch Experiment Station, Midville, Georgia.

4/ These unpublished data were supplied in a private communication from Dr. A. E. Cullison, of the Animal Husbandry Department, University of Georgia, Athens.

5/ M. R. Cooper, A. J. Clawson, and E. B. Barrick, "The Contribution of Various Dehydrated Forage Meals to Growth Performance and Liver Stores of Vitamin A of Swine," A. I. Report 39, A. H. Series 28, mimeographed, North Carolina Agricultural Experiment Station.

Table 11

GRINDING AND PELLETING COASTAL BERMUDA GRASS HAY FOR WINTERING CALVES.

	Group I	Group II	Group III
	Coastal Bermuda grass hay, full fed + 2 lbs. cottonseed meal and 0.10 lb. minerals per head daily	Ground Coastal Bermuda grass hay full fed + 2 lb. cottonseed meal and 0.10 lb. minerals per head daily	Pelleted Coastal Bermuda grass hay full fed + 2 lb. cottonseed meal and 0.10 lb. minerals per head daily
No. of calves	12	12	12
Days on test	133	133	133
Av. initial wt., lb.	437.4	433.5	443.3
Av. final wt., lb.	534.4	580.7	636.4
Av. total gain, lb.	97.0	147.2	193.1
Av. daily gain, lb.	.73	1.11	1.45
Av. daily ration:			
Coastal Bermuda grass			
Hay 1/	10.30	----	----
Meal 1/	----	13.38	----
Pellets 1/	----	----	14.36
Cottonseed meal	2.00	2.00	1.91 2/
Minerals 3/	.10	.10	.10
Total	12.40	15.48	16.37
Av. daily feed consumption as a percent of Group I's intake	100.0	124.8	132.0
Feed per lb. of gain, lb.	17.0	13.9	11.3

1/ The same material except for the physical form in which it was fed.

2/ Calves preferred coastal pellets to CSM. Did not eat their CSM initially. Were forced to eat CSM after the first day or so by mixing it with the pellets.

3/ Consisted of 2 parts defluorinated phosphate and 1 part salt.

Source: Private communication from Dr. A. E. Cullison, Animal Husbandry Department, University of Georgia, Athens.

Table 12-A

COMPOSITION OF RATIONS USED IN STUDYING THREE ROUGHAGES AS SOURCES OF CAROTENE FOR SWINE.

	Alfalfa Meal		Bermuda Grass		Sericea Lespedeza		Control Vitamin A 1/ & B Cplx.	Plus Vitamin B Cplx.
White corn	79.05	73.55	79.05	73.55	79.05	73.55	81.55	81.55
Soybean meal	15.5	14.0	15.5	14.0	15.5	14.0	16.0	16.0
Dehydrated forage	3.0	10.0	3.0	10.0	3.0	10.0	--	--
Limestone	.7)							
Defluorinated Phos.	1.0)		Same for all rations					
T. M. salt	.5)							
Vit.-antibiotic supp.	2.45)							
	100							

Average crude protein 15.5%

Average crude fiber -3.03 for 3% forage levels, 5.24 for 10% level and 2.04% for the control rations.

1/ 1.36 mg. of Vitamin A palmitate in dry carrier added per pound of ration.

Source: M. R. Cooper, A. J. Clawson, and E. B. Barrick, "The Contribution of Various Dehydrated Forage Meals to Growth Performance and Liver Stores of Vitamin A of Swine," A. I. Report 39, A. H. Series 28, mimeographed, North Carolina Agricultural Experiment Station.

Table 12-B

COMPARISON OF DEHYDRATED ALFALFA, COASTAL BERMUDA GRASS AND SERICEA LESPEDEZA WITH A COMMERCIAL VITAMIN A SUPPLEMENT FOR GROWING PIGS.

	Feeding Regime							
	Dehy. Alfalfa		Dehydrated Bermuda Grass		Dehydrated Sericea Lespedeza		Control	
	3%	10%	3%	10%	3%	10%	+A +B Vitamin	+B Vitamin
No. pigs per lot	13	13	13	13	13	13	13	13 1/
Av. init. wt., lbs.	45	49	48	46	45	44	42	44
Av. final wt., lbs.	208	196	202	195	199	193	205	171
Av. daily feed	6.90	6.72	6.77	6.86	6.82	7.03	6.48	5.74
Av. daily gain to final wt., lbs.	1.77	1.58	1.70	1.61	1.68	1.63	1.75	1.49
Feed per cwt. gain, lbs.	389	426	398	426	405	433	370	385

1/ One pig was removed because of a badly infected jowl. Other pigs showed some infection. One pig died in this lot apparently from spraddling and injury on ice. This may have been aggravated by Vitamin A deficiency. Five pigs in this group reached market weight, the other six pigs became night blind and very weak in the rear quarters. One pig was unable to stand on its rear legs when the experiment terminated.

Source: M. R. Cooper, A. J. Clawson, and E. B. Barrick, "The Contribution of Various Dehydrated Forage Meals to Growth Performance and Liver Stores of Vitamin A of Swine," A. I. Report 39, A. H. Series 28, mimeographed, North Carolina Agricultural Experiment Station.

Table 12-C

CARCASS MEASUREMENTS AND LIVER STORAGE OF VITAMIN A FOR PIGS FED THREE ROUGHAGES AS A SOURCE OF CAROTENE

	Dehydrated Alfalfa Meal		Dehydrated Bermuda Grass		Dehydrated Sericea Lespedeza		Control Vitamin A & B Cplx.	Plus Vitamin B Cplx.
	3%	10%	3%	10%	3%	10%		
Carcass length, in.	28.1	28.3	28.8	28.8	28.8	28.4	28.4	28.6
Av. backfat, in.	1.35	1.53	1.57	1.39	1.65	1.49	1.50	1.41
Av. area of loin eye muscle, in.	4.03	3.59	3.99	4.02	3.66	3.65	3.39	4.14
Av. Vit. A (mg/grams of liver)[1/]	5.90	24.21	7.02	24.23	8.69	27.39	109.10	0.67

1/ Liver samples from at least 4 pigs per treatment.

SUMMARY:

1. Pigs fed a white corn-soybean meal ration became sluggish, developed a staggering gait and one pig lost control of its rear legs after 80 days on test.

2. Pigs fed rations containing 3% of roughage as dehydrated meal gained faster and required less feed than those fed 10% of forage meals. However, the liver storage of Vitamin A was higher for pigs fed the 10% level.

3. There was no difference observed in carcass measurements resulting from the treatments tested.

Source: M. R. Cooper, A. J. Clawson, and E. B. Barrick, "The Contribution of Various Dehydrated Forage Meals to Growth Performance and Liver Stores of Vitamin A of Swine," A. I. Report 39, A. H. Series 28, mimeographed, North Carolina Agricultural Experiment Station.

March 12, 1959. Again, Coastal Bermuda seems to be as effective as alfalfa.[6] (Table 13.)

Summary

It should be emphasized that research in the feed value of Coastal Bermuda is still in its infancy. The conclusions of most of the reports issued so far are tentative. However, the fact that similar preliminary results (equality with alfalfa) have been obtained by research in at least three different states is impressive.

To attain the degree of proof desired by the professional nutritionists who have the responsibility of advising the feed industry, it may be necessary to obtain data from a larger number of experiments. Research programs for obtaining more data are underway.[7] The question pertinent to the purpose of this report is whether or not the evidence so far obtained is sufficient to justify an economic feasibility study. The answer must be somewhat subjective. Any objection that might be raised must overcome the force of the argument for early entry into commercial production, if production should prove feasible from other than economic considerations.

The fact that commercial production is already planned in North Carolina, and that production for private consumption is being started in Georgia this year must also be considered. It seems inevitable that there will be a growing number of persons who will be interested in the dehydration of Coastal Bermuda.

6/ D. L. Handlin, et al, "Comparison of Dehydrated Coastal Bermuda Meal, Dehydrated Alfalfa Meal, and Synthetic Vitamin A on the Rate and Efficiency of Gain and Vitamin A Blood Levels of Fattening Swine," A. H. Series No. 8, mimeographed March, 1959. Agricultural Experiment Station, Clemson Agricultural College, Clemson, South Carolina.

7/ See Section VI.

Table 13-A

RATE AND EFFICIENCY OF GAINS FOR PIGS FATTENED IN DRY LOT

Treatments	1	2	3	4
Number of pigs	14	13 1/	14	14
Average initial wt., lbs.	44.4	44.9	44.4	44.4
Days on test	97	97	102	100
Av. daily gain, lbs.	1.59	1.60	1.49	1.57
Av. final weight, lbs.	198.3	199.9	196.3	200.8
Feed per 100 lbs. gain:				
Corn, lbs.	312	309	334	293
Supplement, lbs.	59	46	67	53

1/ One pig died at the start of the test.

Table 13-B

CHEMICAL COMPOSITION AND FORM OF SUPPLEMENTS

Treatments	1	2	3	4
Parts of supplements	½ Fishmeal ¼ Alfalfa meal ¼ Soybean meal	½ Fishmeal ¼ Coastal B. meal ¼ Soybean meal		½ Fishmeal ½ Soybean meal plus Vit. A Premix
Form of supplement	Pelleted	Pelleted	Meal	Pelleted
Crude protein, %	43.75	44.06	45.94	48.13
Ether extract, %	5.08	4.53	5.45	4.51
Crude fiber, %	6.01	6.01	7.19	3.08
Nitrogen-free-extract, %	20.59	20.40	15.23	19.11
Calcium, %	3.27	3.71	3.40	3.12
Phosphorus, %	1.40	1.40	1.44	1.49
Carotene, mcg/gm.	20.80	72.05	72.00	
Vitamin A, mcg/gm.				87.00

Source: D. L. Handlin et al, "Comparison of Dehydrated Coastal Bermuda Meal, Dehydrated Alfalfa Meal, and Synthetic Vitamin A on the Rate and Efficiency of Gain and Vitamin A Blood Levels of Fattening Swine," A. H. Series No. 8, mimeographed March, 1959. Agricultural Experiment Station, Clemson Agricultural College, Clemson, South Carolina.

VI. Research in Progress

Occasional references have been made to research programs from which the data cited have been selected. At North Carolina State and Clemson, fairly comprehensive programs are underway to investigate a broad area of problems related to the cultivation and processing of Coastal Bermuda, as well as animal nutrition. The University of Georgia experiment stations, which performed much of the original basic research, have concentrated on the agronomic and nutritional aspects.

By supplementing the results of this research with a broad economic feasibility study, enough information should become available to enable interested persons to decide whether to enter production of dehydrated Coastal Bermuda meal.

North Carolina State

The program at North Carolina State is a cooperative one, between a private firm and the School of Agriculture. This approach has proven fruitful in several respects, not the least of which is approval, by the State Department of Agriculture, of Coastal Bermuda meal as a substitute for alfalfa meal in animal feeds.

McNair's Yield-Tested Seed Company, Laurinburg, North Carolina, has installed a dehydrating and pelleting plant for processing of Coastal Bermuda and Sericea. The processed material is made available to the School of Agriculture, which performs the feeding tests and evaluates the results. One of the significant advantages of such a cooperative program from the agricultural school's point of view is the direct access to all phases of production, from planting and crop management to storage of the final product. At the same time, it has been possible to avoid tying up station funds in processing equipment.

Pertinent research results published in 1958 have been cited elsewhere. It is understood that this type of cooperative research will be continued.

Clemson

In 1958, the Agricultural Engineering Department at Clemson installed a pilot plant for dehydrating and pelleting Coastal Bermuda. The program currently underway "will include work on such basic problems as plant operation, economic evaluations, animal performance, and stability of pellets--

both physical and chemical--in storage."[1]

University of Georgia

Agronomic experiments in 1959 will include studies of the effect of nitrogen rate and method of application upon protein, fiber and carotene in Coastal Bermuda grass, as well as the effect of frequency of cut on carotene, fiber, lignin and Vitamin C content. Supplemental fertilization will include boron and manganese sulfate.

Feeding trials will doubtless be continued, but the details are not known.

1/ Ernst B. Rogers, Jr. "Dehydrating and Pelleting Coastal Bermuda Grass." Project No. 406 (Part II), Annual Report, 1958 Agricultural Engineering Department, S. C. Agricultural Experiment Station, Clemson, South Carolina, p. 20.